BBC RD 1978/29

BBC

RESEARCH DEPARTMENT

1974 THE QUEEN'S AWARD TO INDUSTRY

REPORT

"CARFAX" TRAFFIC INFORMATION SERVICE: a general description of the ring system

S.M. Edwardson, C.Eng., M.I.E.E.

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION

November 1978

BBC RD 1978/29
UDC 656.11:
621.376.3

"CARFAX" TRAFFIC INFORMATION SERVICE: A GENERAL DESCRIPTION OF THE RING SYSTEM

S.M. Edwardson, C.Eng., M.I.E.E.

Summary

This Report is one of a series concerned with the proposed BBC "CARFAX" traffic information system. It discusses a problem encountered with an earlier proposal and describes the ring system as a possible solution to this problem. The Report also looks in general terms at the features and options of the ring system.

Issued under the authority of

Head of Research Department

Research Department, Engineering Division,
BRITISH BROADCASTING CORPORATION

November 1978

(EL-145)

"CARFAX" TRAFFIC INFORMATION SERVICE: A GENERAL DESCRIPTION OF THE RING SYSTEM

Section	Title	Page
	Summary	Title Page
1.	Introduction	1
2.	Methods of controlling the service area	1
	2.1 The original proposal	1
	2.2 Local field-strength variations	1
	2.3 Variations in receiver activation thresholds	1
	2.4 Some possible measures	2
	2.5 Ring system: general principle	2
3.	Form of receiver for use with the ring system	4
	3.1 Motor vehicle installations	4
	3.2 Domestic receivers	4
4.	Coverage aspects	4
	4.1 Relative power of the ring transmitters	4
	4.2 Coverage of the UK	4
	4.3 Transmitter power requirements	6
	4.4 Transmitter failure	7
	4.5 The effects of field-strength fluctuations	7
	4.6 Co-channel interference	7
	4.7 Adjacent-channel interference	7
5.	Related aspects	8
	5.1 Network control	8
	5.2 Transmitter specification	8
	5.3 Additional FINISH code signals	8
	5.4 Motorway operation	8
	5.5 Additional coded signals	8
6.	Conclusions	8
7.	References	8

"CARFAX" TRAFFIC INFORMATION SERVICE: A GENERAL DESCRIPTION OF THE RING SYSTEM

S.M. Edwardson, C.Eng., M.I.E.E.

1. Introduction

The idea of establishing a dedicated traffic information service, outside the normal domestic radio networks, has been under examination by the BBC for a number of years. In such a dedicated system, a simple, low-cost, fixed-tuned receiver in the motor vehicle would be activated by a special broadcast signal, enabling the normal car radio output or other in-car entertainment to be interrupted and local traffic information announcements to be heard.

The BBC proposal, which has now become known as "CARFAX", has been designed to concentrate upon the requirements of local traffic although, of course, items of long-range interest could also be included in local announcements. The ability to focus upon local traffic problems is achieved by using a large number of low-power stations, each serving a small area of the UK; the transmitters would operate on a time-sharing basis and would all use the same carrier frequency. Time-sharing would be possible because only a small number of transmitters (about five) would be required to broadcast messages simultaneously, and these would be separated geographically to avoid mutual interference. Nationwide coverage could be achieved by about eighty medium-wave stations, although more than 80% of the road traffic in the UK could, in fact, be covered by about twenty stations.

The principles of this basic proposal have been described in detail elsewhere[1,2]. The object of this Report is to consider and propose a solution to the problem of ensuring that motorists reliably receive announcements only from their local transmitters; in other words, to ensure that the service area of each transmitter is controllable and well-defined.

2. Methods of controlling the service area

2.1 The original proposal

When the BBC proposal was first introduced[1,2], the motorist's special receiver was designed to be activated ("de-muted") whenever the received field-strength from the local transmitter exceeded a prescribed value of 3 mV/m. This criterion for activation of the receiver was soon followed by an important improvement whereby special coded signals were transmitted before and after each traffic information message. The coded signals were arranged to operate a latch in the receiver, which thereby remained activated for the duration of the message; this avoided fragmentation or break-up of messages caused by fluctuations in signal-strength and consequential erratic operation of the level-sensitive circuits in the receiver.

Notwithstanding this improvement, the need for consistent and reliable activation of receivers inside (but not outside) the prescribed service area still remained a problem. Ideally, two requirements would both need to be met.

(i) The distribution of field-strength should be such that, anywhere in each prescribed service area, a field-strength of at least the planned value (3 mV/m) would be obtained, with lower field-strengths outside the area.

(ii) The motorist's special low-cost receiver should be able to discriminate reliably against field-strengths below 3 mV/m, but be activated by the stronger signals intended for reception.

The likely practical realisations were examined and found to be far from these ideals:

2.2 Local field-strength variations

Extensive measurements were made by Service Planning Section of the BBC Research Department to determine the pattern of m.f. signal-strength variation over some 2000 route-km in South-East England. The results may be summarised as follows.

(i) The fluctuations in m.f. signal-strength received by a vertical 'whip' aerial, whilst travelling along roads, cover a range of about 10 dB, formed roughly from increases of 4 dB and decreases of 6 dB around the local average.

(ii) The field-strength in urban areas can be some 8 to 10 dB lower than the field-strength in adjacent rural areas. Thus, in a fringe-area town, a receiver may fail to be activated in spite of the fact that, in the surrounding countryside, the field-strength is more than adequate for the purpose.

The effects of (i) and (ii) result in service areas with rather indefinite outer limits and which may contain pockets of low signal-strength.

2.3 Variations in receiver activation thresholds

To become activated upon receipt of a signal with a field-strength of 3 mV/m or more, it is necessary for the aerial and receiver combination to have an activation threshold of reasonable absolute accuracy.

Consideration was given to some possible causes of variation in the performance of car receiving installations and these led to the conclusion that receiver activation thresholds could vary by more than 20 dB. Of course, in practice, some effects will compensate each other and, taking a more optimistic view and combining all the causes of error on an r.m.s. basis, the resulting range of

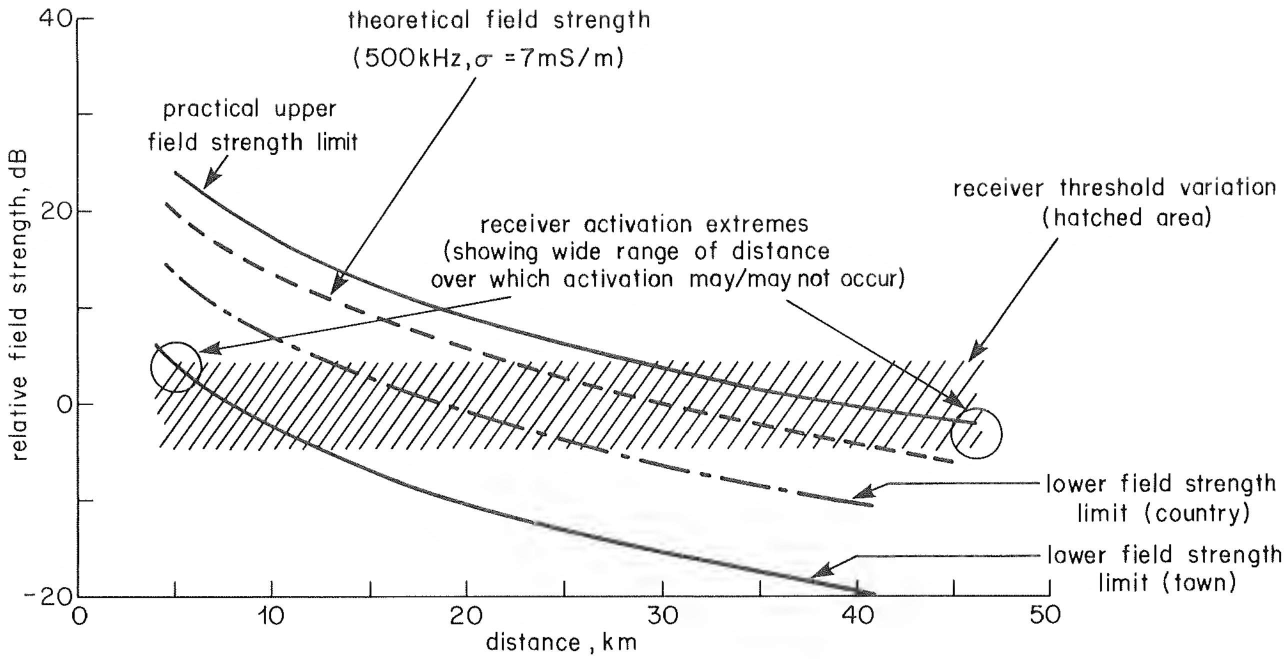

Fig. 1 - Level-dependent receiver activation: effect on service area limits of fluctuations in field-strength and variations in receiver activation threshold.

variation might be about 8 dB. Figure 1 illustrates the effect graphically and it will be seen that, taking the 8 dB range of threshold values in conjunction with the likely range of signal-strength fluctuation described in Section 2.2 above, the limit of the service area, as defined by receiver activation, could be located over a wide range of distances from the transmitter.

2.4 Some possible measures

Consideration was given to driver-operated controls that might be used to compensate for some of the effects outlined above. For example, a sensitivity control might be provided in which increasing sensitivity would give increasing information, by lowering the activation threshold of the receiver, and vice versa. This control could be combined with a "town and country" sensitivity-switch. It was felt, however, that such controls alone would be insufficient and almost impossible to operate in practice and that activation of receivers should be entirely automatic.

It was decided that a different approach to the problem was required. In the search for a solution, the possibility arose that a criterion for receiver activation could be obtained by comparing the strengths of the signals received from the nearest two or three transmitters in the network. Most of the automatic or adaptive methods that were considered were based upon this general principle.

It is not proposed, here, to describe in detail the many alternatives that were examined before arriving at what is thought to be a satisfactory solution. Methods were considered, for example, in which the receiver activation threshold adapted automatically over a period of time to the local field-strength, so that the receiver would be activated only by the strongest (local) signal. Other approaches involved powering groups of transmitters in a sequence that would enable circuits in the receiver to identify (as the strongest) the local station and thereby to discriminate against other, weaker, signals. These considerations led to the Ring System, described in outline in the next Section, and more fully in a companion Report[3].

2.5 Ring system: general principle

The basic principle can be understood with reference to Figure 2 which shows part of an idealised lattice of traffic information transmitters, similar to that already described. Every transmitter has two modes of operation; each may operate either in the message-carrying mode or in the "ring" mode. Transmitter T_0, in this case, is the transmitter carrying the traffic information message. The six surrounding transmitters, T_1 to T_6, are here serving as ring transmitters* and are energised at reduced power for a short period, as described below.

Figure 3 shows the sequence of events. The message transmitter first radiates a START f.m. coded signal to precede its message. This consists of frequency-modulation of the carrier by a 125 Hz tone, with a peak deviation of ± 2 kHz; an f.m. demodulator and 125 Hz filter in the receiver enable the START signal to be detected and the receiver to be activated. Simultaneously, c.w. signals are radiated from the six ring transmitters; these signals begin just before the commencement of the START signal from the message transmitter and end just afterwards. The ring transmitters remain off at all other times.

* Throughout this Report the term 'ring transmitter' is used to describe a transmitter operating in the 'ring' mode and the term 'ring signal' is used to describe the signal radiated by a ring transmitter.

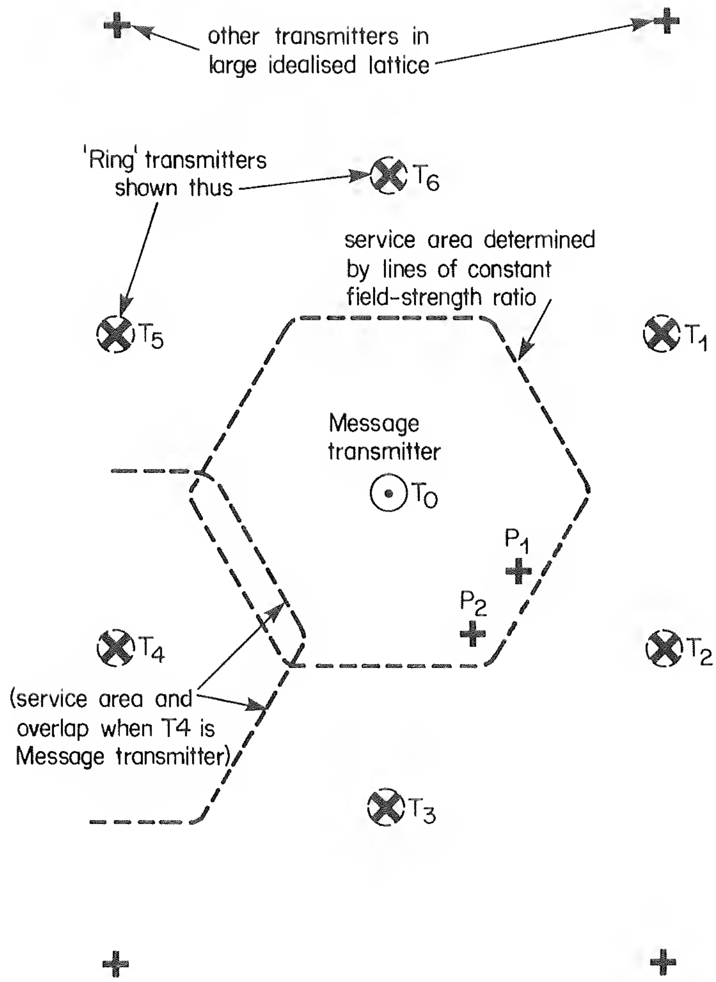

Fig. 2
Ring system: principle of operation

Now consider a receiver located in the region of P_1 (Figure 2), receiving signals predominantly from transmitters T_0 and T_2. If the carrier-level from the ring transmitter T_2 is sufficiently strong, "f.m. capture effect" will cause the START signal from T_0 to be suppressed and the receiver will not be activated. Alternatively, if the signal from the ring transmitter T_2 is not strong enough, the START signal will not be suppressed, the receiver will be activated and the message that follows will be heard. With the signal parameters chosen, capture effect by a single ring signal is very pronounced; a 4 dB increase in the carrier-level of the interfering ring signal causes a 30 dB increase in the level of the demodulated START tone in the receiver[3,4]. Where more than one ring transmitter contributes significantly to the

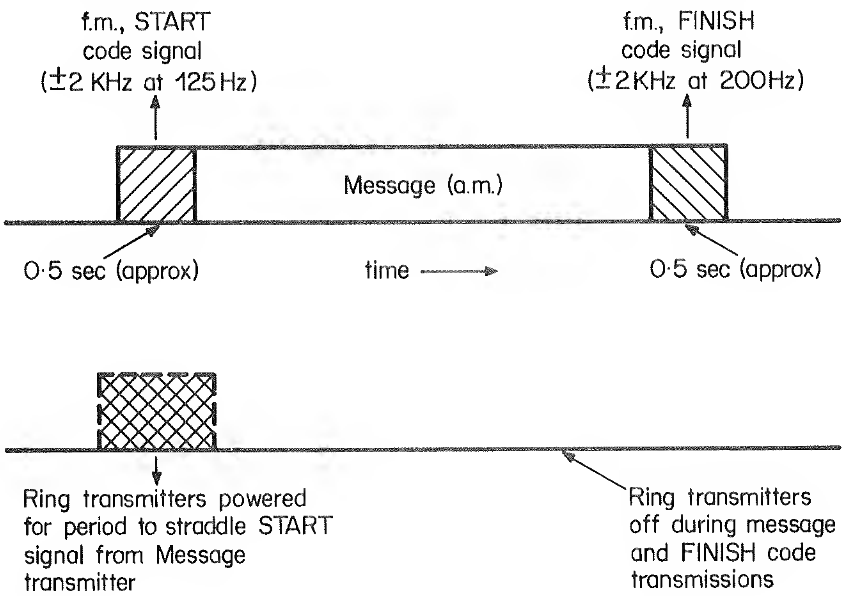

Fig. 3
Ring system: sequence of events

received signal, such as at P_2 in Figure 2, capture effect still operates but is less pronounced[3].

Thus it will be seen that receiver activation is determined by the ratio of the "message-to-ring" signal-strengths rather than their absolute values. The encircling ring of transmitters creates a well-defined limit to the service area of the message transmitter – a kind of controlled jamming – which inhibits reception of the f.m. START signal so that, outside the service area, receivers are not activated and the message is not then heard.

To overcome the difficulties that might arise with particular carrier phases of the c.w. signals from the ring transmitters, these signals are, in fact, frequency-modulated by l.f. random noise, with an r.m.s. deviation of about 400 Hz[3]. This ensures that, during the START code decision-period in the receiver, the signals from the ring transmitters can be averaged satisfactorily.

At the end of the message, a FINISH signal is transmitted to de-activate the receiver. Again, frequency-modulation of the message transmitter is used with a peak deviation of ± 2 kHz, but at a modulation frequency of 200 Hz. During transmission of the FINISH code signals, the ring transmitters remain off and reception of the FINISH signal is then possible down to very low signal-strengths and under conditions of heavy interference. This is thought to be a valuable feature to minimise the number of receivers inadvertently left activated after reception of a message; this could occur, for example, because the vehicle was passing under a bridge during the FINISH signal.

Tests of the ring system have been carried out both in the laboratory and the field[5] and have given very encouraging results. The signal parameters chosen are thought to be optimal, but may be varied during the public trial now being planned.

3. Form of receiver for use with the ring system.

3.1 Motor vehicle installations

Two basic forms of receiver are envisaged. The first is an add-on unit and the second is an integrated unit, in which the circuits of a "CARFAX" receiver are embodied in a conventional car radio.

The add-on unit can either operate alone or be added to an existing installation. In the latter case, separate or split aerial-feeds are required and arrangements also have to be provided for automatic changeover of the loudspeaker connections to the output of the traffic information receiver, whenever it is activated, and vice versa. With this arrangement, normal radio listening to any station is possible and the traffic service (if selected) will cut-in automatically whenever a message is to be received. In some cases it may be preferred to have the new unit operating completely independently, using its own loudspeaker close to the driver. This is technically simple and could also be the basic arrangement for motorists not wishing to have normal car radio facilities.

The integrated unit operates in a similar manner to the add-on unit, but is, of course, more compact and cheaper, if the additional cost of the complete car radio is considered.

Figures 4 and 5 show photographs of prototype add-on and commercially-manufactured receivers, respectively; these prototypes are somewhat larger than production models are likely to be. Figure 6 gives a block diagram of a basic integrated receiver. Further details of receiver aspects are given in a companion Report.[6]

It is not yet possible to give an accurate estimate of the cost of future commercially manufactured receivers. Provisionally, it is suggested that an add-on unit might, with large production, cost in the region of £10, and that the additional cost in a combined receiver would be somewhat less than this.

3.2 Domestic receivers

Traffic information messages could also be received in a similar way by domestic radio receivers, if they were fitted with a "CARFAX" receiving module for the purpose. This could be an important aspect of a traffic information service. Breakfast-time is a peak radio listening time and considerable use might be made of traffic information by motorists before they take to the road (or decide not to do so).

Similar circuit arrangements to those shown in Figure 6 could be used for a domestic receiver, although a substantially omni-directional aerial would in many cases be preferable for the "CARFAX" receiver section.

4. Coverage aspects

4.1 Relative power of the ring transmitters

It is clear that the power radiated by a ring transmitter will affect the ratio of the "message-to-ring" signal-strengths and hence the location of the edge of the service area of the message transmitter; an increase in ring transmitter power will push back the message service area, whilst a lowering of the ring power will allow the service area to expand. Experiments indicate that, if the power of each transmitter in the ring is lower by about 6 dB to 7 dB than the power when radiating a message, this should result in about the right degree of overlap between adjacent service areas.

The number of ring transmitters need not, of course, be six but can vary according to local requirements. Moreover, the power radiated by a particular ring transmitter may be made dependent upon which particular adjacent transmitter is carrying a message; it is thought that this could be of assistance in planning, since a measure of control of the size and shape of the service area of each transmitter is available by adjustment of the power of each of the associated ring transmitters.

4.2 Coverage of the UK

Figure 7 illustrates in a somewhat idealised way the

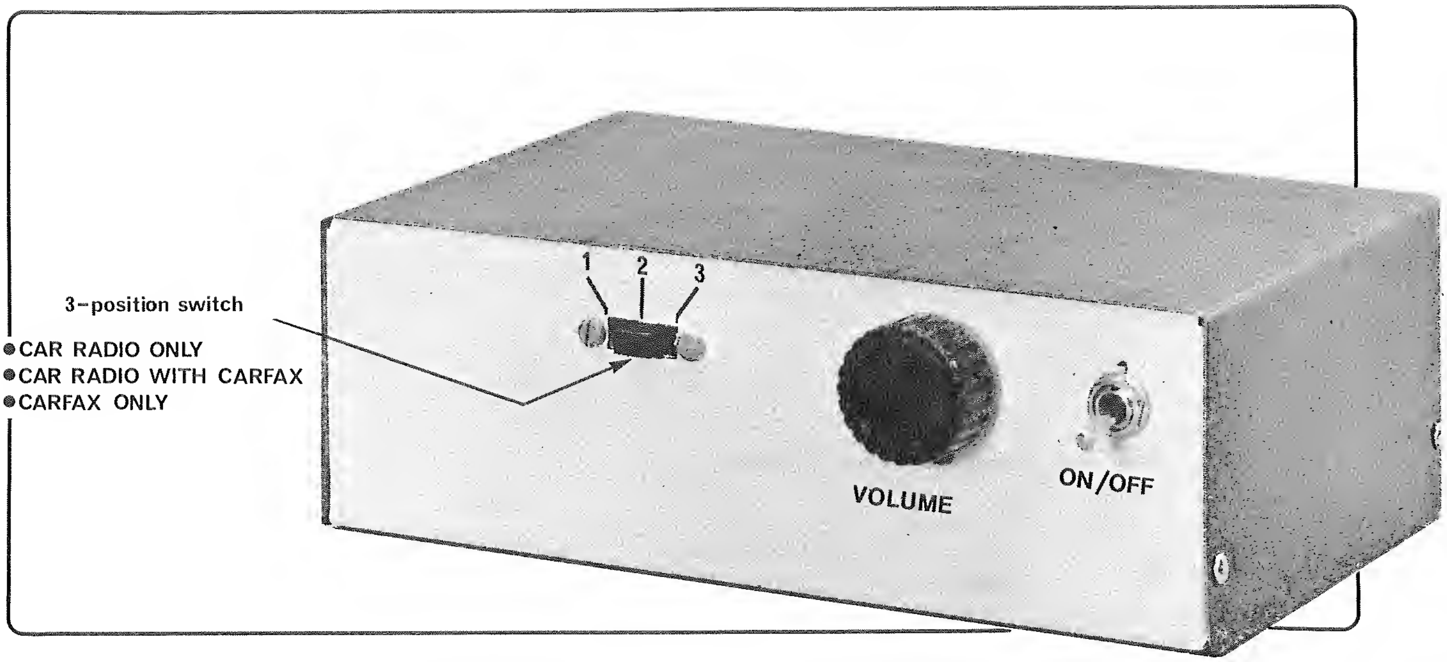

Fig. 4 - Prototype add-on unit.

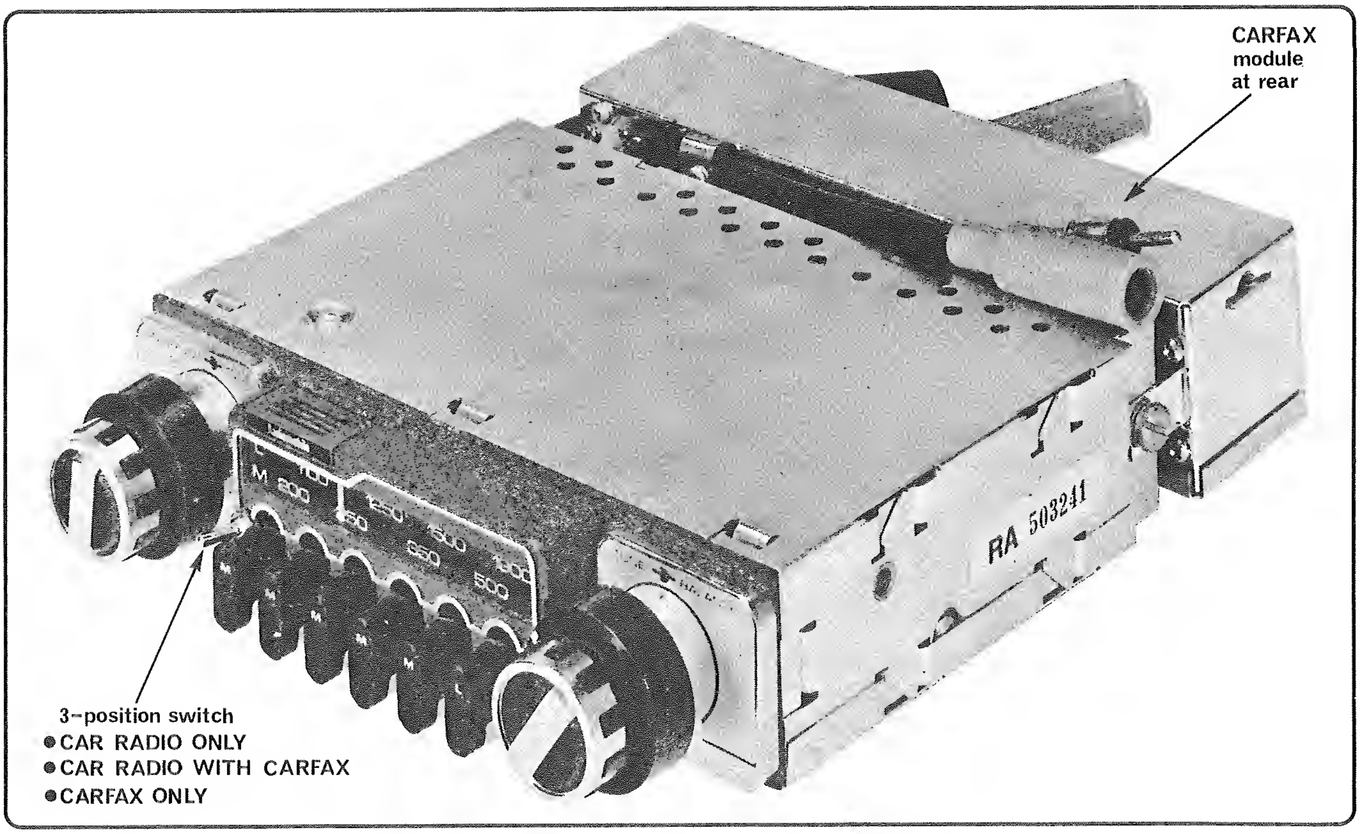

Fig. 5 - Prototype commercial receiver.

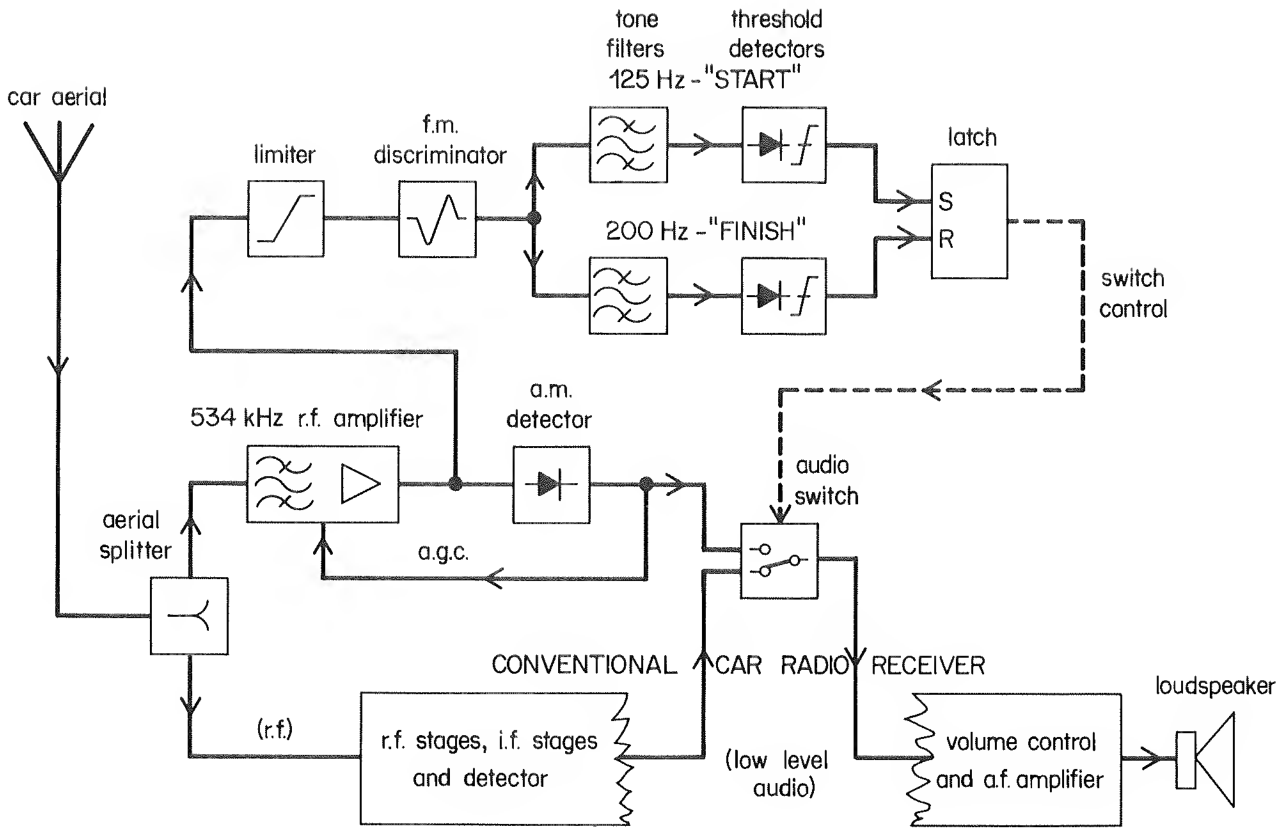

Fig. 6 - Integrated receiver

approximate coverage, of the UK, expected using eighty existing BBC sites. It will be seen that there are no unwanted overlaps or unserved areas; deliberate overlaps would probably be provided, as described in the previous section, but these are not shown in Figure 7. The boundaries of the service areas are likely to be well-defined and largely independent of receiver performance.

4.3 Transmitter power requirements

Since only the relative powers of transmitters affect the service areas, the minimum transmitter power requirement is determined by the need to provide adequate signal-strength for good reception of messages in motor vehicles. Higher overall powers may be used, of course, without affecting the service areas and limited only by international requirements and cost. In practice, a transmitter (message) power of about 500 Watts is expected to be adequate.

One advantage of the proposed system is the relatively low level of total power radiated from the UK at any one time. Assuming six ring transmitters, each at −7 dB, the use of the ring system would roughly double the total radiated power (although for only the occasional fraction of a second of ring signal transmitting time). If a restriction on total radiated power were essential, this could be met by reducing the power of all the transmitters during the transmissions of the START code, so that the total radiated power from the combined message and ring transmitters was contained within any necessary limit.

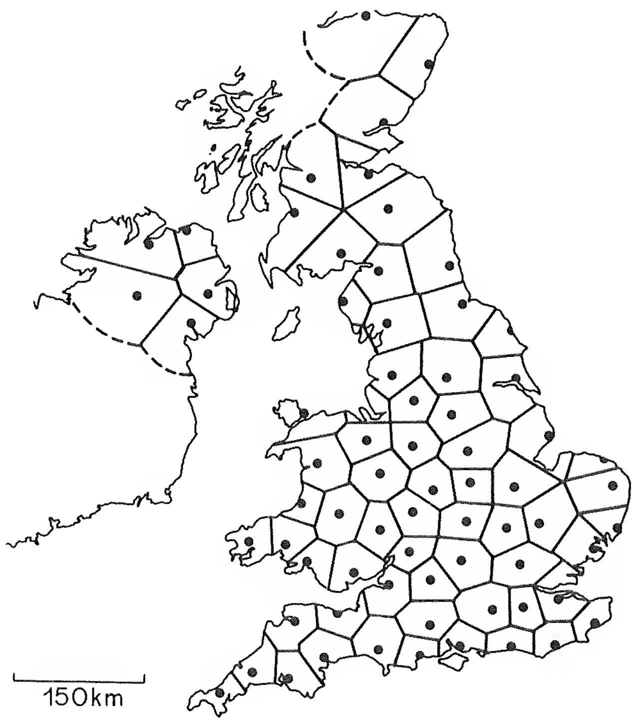

Fig. 7 - Approximate coverage of the UK using eighty existing BBC sites.

4.4 Transmitter failure

It also follows from Section 4.1 that, should a transmitter fail, the lost service area will in most cases be covered by the surrounding transmitters whose service areas will automatically expand to cover most or all that of the failed transmitter. It is thought that this would result in a useful saving in stand-by services and equipment, it being understood that the announcements would be adjusted to conform to the modified service areas. Of course, the standard of reception may be impaired at long ranges, depending upon the overall power chosen for the transmitters, as discussed in Section 4.3 above.

4.5 The effects of field-strength fluctuations

As stated in Section 2.2 and illustrated in Figure 1, measurements show that the m.f. signals received by a car radio receiver fluctuate in level, at times by as much as 10 dB, as the vehicle moves along the road, and that m.f. field-strengths in built-up areas are about 10 dB lower than in the adjacent open country. Although the ring system is insensitive to these effects, relying as it does upon the ratio of the signal strengths received from the ring and message transmitters, it was not known to what extent local fluctuations in signal strength are affected by the direction of propagation. Such fluctuations could clearly have an effect upon the ratio of signals arriving from different directions, and hence, upon the operation of the ring system. A short field-trial to measure the ratios of received signal-strengths in these circumstances was therefore carried out.[5] It was found that, in general, using a whip aerial mounted on a vehicle, the ratio of the strengths of the signals received from two transmitters on the same frequency can vary locally over a range of 2 dB to 3 dB. (The effect of non-uniformity of the horizontal radiation pattern of the receiving aerial would be included in this result but in any case would be less than 1 dB[1]). Wider variations in the ratio of received field-strengths have been found in a few localities and these are thought to be due to overhead wires, steel structures, etc., such as are often found in towns. In the worst cases, fluctuations over a range of 10 dB have been found; these wide fluctuations are confined to relatively small areas.

Thus the effect of local variations in field-strength ratio will be to 'roughen' the otherwise smooth boundaries of the service areas. Since it is expected that an overlap between service areas of a few miles will be required for the proper dissemination of information, the local effects referred to above are not expected to be serious. Nevertheless, consideration is being given to ways of minimising them. For example, because the influences are local and the receiving vehicles will, in general, be in motion, it may be found worthwhile to use a START signal of longer duration than at present, in conjunction with a longer time-constant in the "CARFAX" receiver.

4.6 Co-channel interference

Co-channel interference can be created by other message transmitters in the "CARFAX" traffic information network sharing the same time period, and, if a clear channel is not available, by stations of other services. It is necessary to consider also the interference which might be caused by the f.m. coded START and FINISH signals.

(i) Interference from "CARFAX" message transmissions would depend upon both the groundwave and sky-wave signals that would occur when using a very large network of transmitters. Work is still in progress on this aspect, but present indications are that, given a clear channel, the "CARFAX" system could successfully operate throughout a large area such as Western Europe; this assumes a transmitter duty-factor of 6% (i.e. each transmitter could radiate for 1/16 of the total time) which is thought to be more than adequate for traffic information purposes.

(ii) Interference to or from other services depends, of course, on the choice of frequency. If the service were not given a clear channel and had to operate within the broadcasting bands, night-time interference could be excessively high (although day-time interference levels would be negligible) and (i) above could not be realised. Reciprocally, because the total radiated power from the "CARFAX" network at any time is likely to be low and distributed over a large area, it is unlikely to constitute a serious new source of interference to existing or planned broadcasting stations.

(iii) Interference from the START and FINISH coded signals is expected to be a potential source of trouble when an area is quiescent, i.e. when local transmissions are not taking place but a START signal is radiated by a distant "CARFAX" station. In this case, a "false-start" may occur[3] and a motorist would then receive a weak and irrelevant message; this problem is likely to occur because of the rugged nature of the f.m. coded signals, which can penetrate down to very low field-strength values and through conditions of heavy interference. Various solutions are possible. For example, in a quiescent area, a transmitter could be powered, but without modulation. This would provide a protective "blanket" of c.w. signal against unwanted START signals, preventing activation of receivers by "capture effect" in exactly the same way as the ring transmitters. Protection against unwanted de-activation by remote FINISH signals, similarly, is automatically provided by the stronger carrier from the local message transmitter.

Interference from the f.m. coded signals may also be heard when a START or FINISH signal is radiated by a distant station during a local message transmission period. Such interference would be very brief and may not be disturbing; however, tests are in progress to assess its importance. The results of these tests will be of assistance in determining the form of network control.

4.7 Adjacent-channel interference

The problems here are of a similar kind to those in conventional a.m. broadcasting. However, the require-

ment for only speech-transmission permits the use of a relatively narrow transmitted bandwidth, with good protection from adjacent-channel interference. Moreover, it is envisaged that "CARFAX" receivers will employ block r.f. filters, perhaps of the ceramic type. Good selectivity is easily and cheaply obtained with this kind of filter which will have a narrow pass-bandwidth to match that occupied by the transmitted "CARFAX" signal. Thus, adjacent-channel interference with other services both to and from "CARFAX" is expected to be less than that normally experienced in the m.f. band.

5. Related aspects

5.1 Network control

The switching and feeding of a network of transmitters, together with the control and processing of information, will probably require the use of one or more small computers. The form of control will depend upon the number of control centres, which will be connected to the transmitters by land-lines, and will require to be interdependent to some extent.

It will be necessary to establish a number of basic rules and priorities, before setting-up the network, particularly with regard to simultaneous transmissions, (see Section 4.6) the alternative "message" and "ring" roles of the transmitters, etc. Computer control will make it possible to change these rules as the situation dictates, e.g. to accommodate day- and night-time propagation conditions, and to accommodate rush-hour traffic.

5.2 Transmitter specification

The transmitter requirements are unconventional in two ways. First, it is necessary both to amplitude-modulate and to frequency-modulate each transmitter, although not simultaneously. Second, it is necessary to operate each transmitter at different output power levels.

Recent developments in small solid-state transmitters lend themselves readily to the adjustment of output power, without gross inefficiency. The need to frequency-modulate the carrier has been found not to be a serious additional requirement, particularly as good linearity is not required.

5.3 Additional FINISH code signals

The proposed parameters of the FINISH code signals are given in Figure 3. Although the f.m. coded signals are very rugged and will penetrate into areas of very low field-strength, there may be times when a FINISH code is missed (such as when a vehicle is passing under a bridge) and the "CARFAX" receiver remains activated. To reduce the irritation caused by this, it is expected that the transmission of additional FINISH codes will be possible so as to 'close-down' any receivers inadvertently left on.

5.4 Motorway operation

It has been suggested that sections of motorways could be served by low-power transmitters with aerials located perhaps in sections along the central reservation. The range of these transmitters would be very restricted, so that their signals could be received only by vehicles on the motorway. The use of the ring system in conjunction with such an arrangement would allow:

(a) Signals intended for the motorway to be received only on the motorway, as above.

(b) Signals intended for the area through which the motorway passes not to be received on the motorway. (Motorway transmitters in this case would be operated in the ring or inhibiting mode).

(c) Signals intended for the area through which the motorway passes also to be received on the motorway. (Motorway transmitters in this case would remain off).

In much the same way, limited areas such as city centres could have separate transmitters of very low power for separate announcements. Such a facility could be considered for temporary special-purpose installations.

5.5 Additional coded signals

Consideration is being given to the transmission of additional coded signals to provide extra facilities. Such signals may, for example, be used to distinguish between old and new messages, or to identify messages intended for various categories of vehicle.

6. Conclusions

A method has been proposed to reduce the problems inherent in the level-dependent method of receiver activation in the BBC Traffic Information Service.

The method, known as the Ring System has been tested both in the laboratory and in the field and has given encouraging results and leads to a number of interesting possibilities.

7. References

1. SANDELL, R.S., HARMAN, M.W., 1975, "A traffic information service employing time division multiplex transmission". BBC Research Department Report No. 1975/9.

2. SANDELL, R.S., HARMAN, M.W., 1975, "A traffic information service employing time division multiplex transmission". BBC Engineering No. 100, June 1975.

3. KALLAWAY, M.J., 1978, "CARFAX" traffic information service: an analysis of the characteristics of the ring system and receiver activation". BBC Research Department Report No. 1978/31.

4. WHYTHE, D.J., 1977, "Traffic information service: the dependence of f.m. capture effect upon modulation index". BBC Research Department Report No. 1977/35.

5. KALLAWAY, M.J., 1978, ""CARFAX" traffic information service: preliminary field assessment of the ring system". BBC Research Department Report No. 1978/30.

6. BAILEY, M.E., 1978, "Traffic information service: requirements for the receiver". BBC Research Department Report in course of preparation.

CJS/SB/VY.
(EL-145)

Printed by BBC RESEARCH DEPARTMENT, Kingswood Warren, Tadworth, Surrey, KT20 6NP